Inspira Crea Transforma

ABMS of the interaction between bees, flowers and insecticides using stochastic differential equations.
Final Presentation

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Modeling and Simulation V

Table of Contents

ODD

1. OVERVIEW

Purpose

The contemporary era is characterized by the desire to predict and forecast the behavior of the phenomena that are part of the world in any aspect of everyday life, whether it is psychology, finance, economics, sociology, physics, among others.

The aspect in question in our investigation is a biological phenomena, involving the interaction between bees, flowers and pesticides. Our goal is to investigate the effects of pesticides on bee populations and their behaviour, specifically, the pollination of flowers.

Entities, state variables, and scales

Bees - *energy, vision-range, probability of reproducing, energy gained from food.*

Flowers - *lifetime, probability of reproducing*

Pesticides - *intensity*

Bees are the only dynamic agents, flowers and pesticides are both static. Only bees interact with the other agents. Flowers and pesticides do not directly interact.

Process overview and scheduling

Each click results in a change in state variables of the model entities. Bees/flowers lose energy, and bees also move position.

If a bee comes into close proximity of a flower, the bee can gain energy.

If a bee comes into close proximity of a pesticide, the bee will lose energy depending on the intensity of the pesticide.

Bees and flowers can both reproduce which results in a drop in energy and another agent of the same type to be initialized.

Both flowers and bees can die if their energy drops below zero.

Once pesticides are initialized, their variables do not change.

2. Design Concepts

Basic principles

The nature of bees.

Study of bee movement.

Effect of pesticides.

Emergence

Important outputs from of the model include population sizes for bees and flowers.

This changes depending on how the simulation runs and is the key output in monitoring population progression.

Population size of pesticides is predetermined at the initialize phase.

Adaptation

Bees are the only agents with adaptive behaviour.

They can change their movemental behaviour if a flower enters their range of vision.

Also, bees can "pollinate" flowers only when they are in the proximity of them. (Indirect object-seeking)

All other behavioural adaptations are solely based on energy level.

Objectives

In this case, bees don't have direct object seeking objectives. The only objective is to survive as a population, which requires reproduction which requires food.

Bees don't compare any options to decide which is best in achieving a specific outcome.

Sensing

Bees can sense flowers at a close proximity and are therefore more likely to visit a flower. Effectively this means the radius of the flower in which a bee must enter to detect and visit the flower is larger, so the probability that a flower gets visited by more bees is larger, thus improving the chances of population survival for both bees and flowers.

The bees "range-of-vision" can be controlled and changed with each simulation.

Sensing mechanisms????How do bees sense flowers????How far can they detect a flower from??????

Interaction

In this simulation only bees interact with flowers and pesticides.

Bees can “eat the flower” gaining some predetermined amount of energy.

Bees can “pollinate” flowers, meaning another flower is produced in the environment.

Bees can interact with pesticides, losing a certain amount of energy.

These interactions are based on real-life processes. Bees do pollinate flowers and gain energy and resources, pollination of flowers results (not as directly in the model) more flowers. Pesticides are toxic to bees - not simply by lowering energy levels - and can wipe out entire colonies if the chemical is brought back to the hive and infects the queen.

Stochasticity

Used to model the movement of the bee agents.

$$\begin{bmatrix} dX_t \\ dY_t \end{bmatrix} = \begin{bmatrix} \alpha_x(\mu_x - X_t) \\ \alpha_y(\mu_y - Y_t) \end{bmatrix} dt + \begin{bmatrix} \sigma_x & 0 \\ 0 & \sigma_y \end{bmatrix} \begin{bmatrix} dBx_t \\ dBy_t \end{bmatrix}$$

Observation

Plots of population size are vital in monitoring the rate of population change. We can see how changing variables affects the rate as it changes from linear to exponential. We can also compare population sizes and rates on the same graph and observe critical points. Which population is generally higher? What happens if they switch? What happens if one population stops growing?

3. Details

Initialization

Bees: *initial population: 5* *gain-from-food: 26*
probability of reproducing: 3% *vision-range: 2.0*

Flowers: *initial population: 15*
probability of reproducing: 3%
lifetime : 180

Pesticides: *initial population: 25*
intensity: 195

Input data

No input data?

Submodels

Bees/flowers lose energy : current energy - 1??????

Bees move position according to movement laws.

If a bee comes into close proximity of a flower, the bee can gain energy: energy + energy-gain-from-food

If a bee comes into close proximity of a pesticide, the bee will lose energy depending on the intensity of the pesticide: energy - intensity of pesticide.

Bees and flowers can both reproduce which results in a drop in energy and another agent of the same type to be initialized: energy is shared between parent and child

Both flowers and bees can die if their energy drops below zero.

BACKGROUND

The movement of animals is related to various variable influences

when the movements are not largely directed or observed for a long time, it can be said that the dynamics of the movement can be described by a correlated random walk. (Lenz, Chechkin, and Klages 2013) propose a generalization of Langevin's stochastic differential equations to analyze by means of experimental data from bumblebee flight. Finally, by parameter estimation, the differences and similarities of the model are discussed.

The study of the behavior of animals is of great importance in practical ecology, for example, it allows analyzing the strategies of searching for food of animals in an ecosystem. Lvy's flights are random walks in which the pitch lengths come from probability distributions with heavy-power law tails. The goodness of fit criteria Akaike and maximum likelihood is applied to four bee and deer datasets in order to identify the presence of Lvy flights. It is concluded that none of them exhibits evidence of Lvy flights and that it is necessary to question the solidity of the empirical evidence for Lvy's biological flights (Edwards, Phillips, Watkins, Freeman, Murphy, Afanasyev, Buldyrev, da Luz, Raposo, Stanley, and Viswanathan 2007). This study allows us to conclude that it is really difficult to properly characterize the movement of bees and their modeling. Regarding the literature, some patterns of stochastic nature have been identified from a Brownian perspective, but it is necessary to clarify that this is an approximation of the movement with respect to what the bees are expected to do in the proposed environment.

DATA OF THE MODEL

Studying the movement of bees is a complicated task involving various variables, parameters and behaviours.

Hypothesis' for this reason are difficult to prove.

Recognizing our lack of concise knowledge allows us to present our model on the basis that it is purely speculative and solely for academic purposes.

An adaptation of the model could be applied to real life if it is validated.

IMPLEMENTATION ON SIMULATION PLATFORM

Our simulation was implemented in NetLogo.

Implementation includes monitors for visualization of principles variables of the model.

Plots of the variables throughout time allow understanding of the evolution of the model.

VERIFICATION AND VALIDATION

EXPERIMENTATION

RESULTS

ANALYZE FROM THE BOTTOM

Flowers are simple agents: their only purposes is to exist for a certain period of time defined by their energy in a determined position and to interact with the bees, providing them food and reproducing through them, hence why their only attribute is energy and their only action is to die when their energy is below 0.

Pesticides that just exist for all the time in the current simulation. They just interact with the bees, reducing the bees energy based in their intensity.

The bees are the most complicated agents in this model, in every tick, they move in a stochastic movement depending on their energy and nearby flowers, they lose energy, they eat if there is a flower near them, they interact with pesticides in the same position of them, they reproduce with a certain constant probability, they leave flowers with a certain probability and if the energy is below zero, they die.

EXITS

The proposed outputs for our model are the total number of bees and the total number of flowers.

We consider the previous state variables as outputs because they are the agents that have a dynamic behavior in the simulation process, that is, they are those that generate dynamism in the model.

These are the values which at the end of the simulation allow us to evaluate the execution of the simulation and decide which parameters we want to change for the next simulation to analyze behaviour in different situations.

STEP BY STEP

The simulation begins with particular initial conditions and the random location of the agents in the field.

Bees: depending on their level of energy -> go to the nearest flower to feed if it requires, otherwise -> moves randomly through the field with the possibility of pollinating a flower.

Flowers; despite being static agents, play a fundamental role in the model. These feed the bees and with the passage of time they diminish their energy until they die.

Finally, the insecticides spray poison to the bees that pass close to them, which affects them negatively, decreasing their energy level.

The interaction between the agents presented above happens in each tic of the simulation.

EXTREME VALUES OF PARAMETERS

Flower reproduce = 0%
All flowers will eventually die with no new ones being produced. Obvious prediction is end result with 0 flowers and 0 bees.

After 100 simulations, this was the final outcome.

Number of Pesticides = 0
Flowers and bees are allowed to mutualistically support one another with no limits. Exponential growth in both populations.

Number of Pesticides = 300
Bees die out quickly, closely followed by flowers. Each simulation stabilized in both populations reaching zero.

SENSITIVITY ANALYSIS

The contemporary era is characterized by the desire to predict and forecast the behavior of the phenomena that are part of the world in any aspect of everyday life, whether it is psychology, finance, economics, sociology, physics, among others.

CONCLUSIONS AND RECOMMENDATIONS

THANK YOU!

Questions?